Design and Development of Lora-Based Wireless Conveyor Metal Sorting System for Industrial Automation

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Abstract: *The increasing demand for industrial automation has created the need for efficient and reliable material handling systems. This paper presents a LoRa-Based Wireless Conveyor Metal Sorting System designed for automatic detection and separation of metallic objects. The system uses Arduino Nano controllers, E32-433T30D LoRa modules, an inductive proximity sensor, a BTS7960 motor driver, and an MG996R servo motor. Objects are transported through a conveyor mechanism, where metallic materials are identified and automatically diverted to a separate collection path. The proposed system reduces manual effort, improves sorting accuracy, and enables long-range wireless control. Experimental results demonstrate reliable communication and efficient sorting performance, making the system suitable for industrial automation applications.*

Keywords: LoRa, Conveyor System, Metal Sorting, Arduino Nano, Industrial Automation, Wireless Control.

I. INTRODUCTION

The rapid advancement of industrial automation has increased the demand for intelligent material handling and sorting systems. Conveyor-based systems are widely used in manufacturing industries, warehouses, and recycling plants for transporting and processing materials. However, traditional sorting operations often rely on manual intervention, which can reduce efficiency, increase labor costs, and lead to sorting inaccuracies. As industries continue to move towards smart manufacturing, the need for automated and reliable sorting solutions has become increasingly important.

Wireless communication technologies have significantly improved the flexibility and scalability of automation systems. Among various communication methods, LoRa (Long Range) technology has gained considerable attention due to its ability to provide long-distance communication with low power consumption and high reliability. These characteristics make LoRa suitable for industrial environments where stable communication and remote monitoring are essential requirements [1].

This paper presents the design and development of a LoRa-Based Wireless Conveyor Metal Sorting System that combines wireless communication, automatic metal detection, and intelligent sorting mechanisms. The system utilizes Arduino Nano microcontrollers, E32-433T30D LoRa modules, an inductive proximity sensor, a BTS7960 motor driver, and an MG996R servo motor. The conveyor mechanism transports objects through the detection zone, where metallic materials are identified and automatically separated from non-metallic objects. The proposed system reduces manual effort, improves sorting efficiency, and enhances operational safety[1] [2].

The transmitter unit enables remote monitoring and control through LoRa communication, while the receiver unit performs object detection and sorting operations. The integration of an LJ12A3-4-Z/BX inductive proximity sensor allows the system to accurately identify metallic objects without physical contact. When a metallic object is detected, the Arduino Nano processes the sensor signal and activates the servo-based sorting mechanism. This synchronized operation ensures accurate separation of materials while maintaining continuous conveyor movement. The developed system offers a cost-effective and scalable solution for industrial automation applications and provides a foundation for future integration with Industry 4.0 technologies.

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Problem Statement

The problem statement for the LoRa-Based Wireless Conveyor Metal Sorting System focuses on the challenges associated with manual sorting operations, limited communication range, and reduced efficiency in industrial material handling processes. The following issues are commonly observed in conventional sorting systems:

In many industries, metallic and non-metallic materials are separated manually, which requires continuous supervision and significant labor effort. In large-scale manufacturing units, warehouses, and recycling facilities, manual sorting operations often result in several operational challenges:

Sorting Inaccuracy: Human operators may incorrectly identify or separate materials, leading to reduced sorting accuracy and inconsistencies in the final output. Such errors can affect production quality and increase operational costs.

Reduced Productivity: Manual inspection and sorting processes are time-consuming and limit the overall throughput of conveyor systems. As production demand increases, maintaining efficiency becomes increasingly difficult

Safety Concerns: Workers operating near moving conveyor systems and industrial machinery are exposed to potential safety risks. Continuous manual intervention can increase the likelihood of workplace accidents.

Communication Limitations: Traditional wired systems require extensive cabling and maintenance, while short-range wireless technologies such as Bluetooth and Wi-Fi may not provide reliable communication in large industrial environments.

Lack of Real-Time Monitoring: Conventional systems often lack effective monitoring and feedback mechanisms, making it difficult to track system performance, operating status, and sorting efficiency in real time.

Maintenance and Scalability Issues: Expanding or modifying existing sorting systems generally requires additional wiring, equipment, and labor, increasing installation complexity and maintenance costs.

To overcome these challenges, there is a need for a wireless conveyor automation system that combines long-range LoRa communication, automatic metal detection, and intelligent sorting mechanisms. The proposed system utilizes Arduino Nano controllers, E32-433T30D LoRa modules, an inductive proximity sensor, and a servo-based sorting unit to provide an efficient, reliable, and cost-effective solution for industrial material handling applications.

Need and Necessity of Project

In conventional industrial sorting systems, metallic and non-metallic objects are often separated manually, which can lead to sorting errors and reduced productivity. This project is needed to improve sorting accuracy. By utilizing an inductive proximity sensor and a servo-based sorting mechanism, the system can automatically identify and separate metallic objects with consistent performance.

Modern industries require reliable monitoring and control over large operational areas. This system is needed to provide long-range wireless communication using LoRa technology. The implementation of E32-433T30D LoRa modules enables stable communication between transmitter and receiver units without relying on internet connectivity, making the system suitable for industrial environments.

Labor costs and operational downtime are significant concerns in manufacturing and material handling industries. This automation system is needed to reduce human intervention and improve overall efficiency. A single operator can monitor and control the conveyor system remotely, resulting in lower operating costs, improved productivity, and easier scalability for future industrial expansion.

II. LITERATURE SURVEY

For the development of the proposed LoRa-Based Wireless Conveyor Metal Sorting System, several research papers and technical studies were reviewed. The selected literature provided valuable insights into conveyor automation, wireless communication, and automated sorting technologies.

“A Study of LoRa: Long Range & Low Power Networks for the Internet of Things” : Augustin A., Yi J., Clausen T., Townsley W.This paper presents the architecture and performance of LoRa communication technology for long-range wireless applications. The study highlights the advantages of LoRa, including low power consumption, high communication reliability, and long-distance data transmission. The findings demonstrate that LoRa technology is

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highly suitable for industrial monitoring and automation systems where conventional wireless technologies face range limitations [8].

"Internet of Things in Industries: A Survey":L. Da Xu, W. He, S. LiThis survey discusses the role of IoT technologies in modern industrial automation. The authors emphasize the importance of sensor-based monitoring, wireless communication, and intelligent control systems for improving industrial productivity and operational efficiency. The paper provides a foundation for integrating smart technologies into industrial material handling systems [7].

"Automation, Production Systems and Computer-Integrated Manufacturing": Mikell P. GrooverThis work explains the principles of automation, conveyor systems, and material handling technologies used in manufacturing industries. The study highlights how automated sorting systems can improve productivity, reduce labor requirements, and increase operational accuracy. The concepts presented in this work were useful in designing the proposed conveyor-based metal sorting system [12].

III. METHODOLOGY

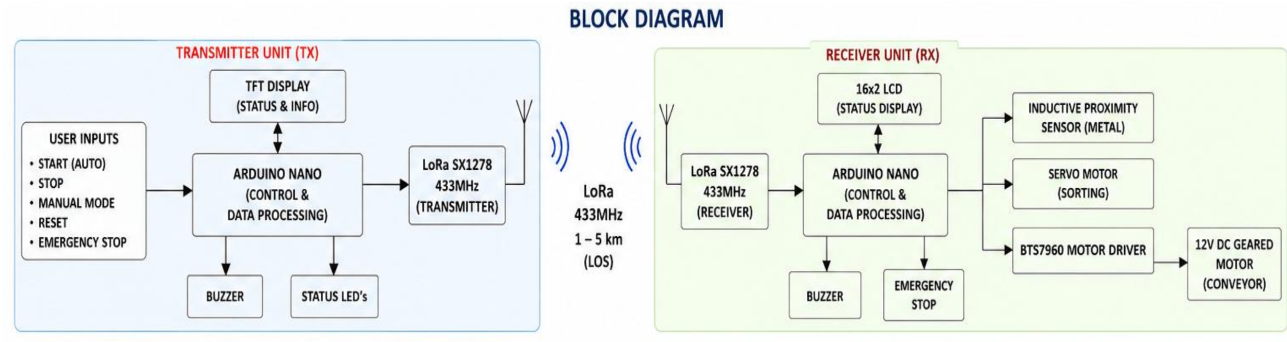

Fig. 1. Block Diagram of LoRa-Based Wireless Conveyor Metal Sorting System

The proposed system consists of a transmitter unit and a receiver unit interconnected through E32-433T30D LoRa communication modules operating at 433 MHz. The transmitter unit includes an Arduino Nano, TFT display, push buttons, buzzer, status LEDs, and an emergency stop switch for system control and monitoring. Control commands are transmitted wirelessly to the receiver unit through LoRa communication.

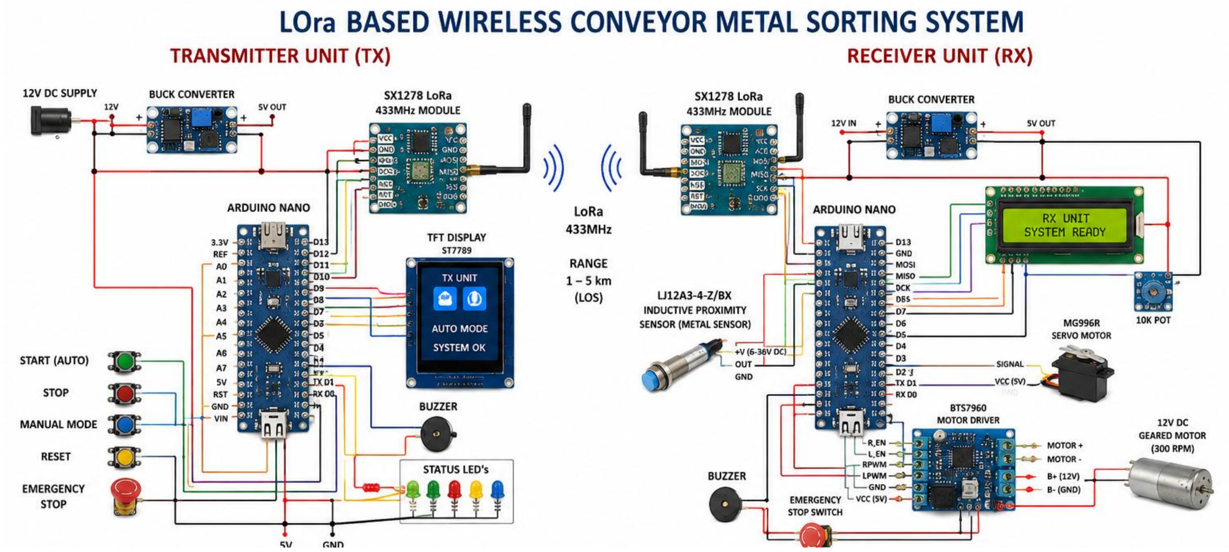

Fig. 2. Circuit Diagram of LoRa-Based Wireless Conveyor Metal Sorting System

The receiver unit consists of an Arduino Nano, E32-433T30D LoRa receiver, 16×2 LCD display, LJ12A3-4-Z/BX inductive proximity sensor, MG996R servo motor, BTS7960 motor driver, and a 12V DC geared motor. The proximity

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sensor detects metallic objects on the conveyor belt, and the Arduino Nano processes the sensor data to control the servo-based sorting mechanism. The BTS7960 motor driver controls conveyor movement, while the LCD display provides real-time system status information. The complete system enables reliable wireless monitoring, automatic metal detection, and efficient sorting operations.

The proposed LoRa-Based Wireless Conveyor Metal Sorting System operates through wireless communication, automatic metal detection, and servo-based sorting mechanisms. The complete operation is divided into three stages.

System Initialization and Wireless Communication

Input: The operator selects the desired operating mode (Auto/Manual) using the transmitter unit buttons. The TFT display shows the current system status and operating mode.Command Transmission: The Arduino Nano in the transmitter unit processes the user input and sends control commands through the E32-433T30D LoRa module operating at 433 MHz.Conveyor Activation: The receiver unit receives the transmitted data through the LoRa receiver module. The Arduino Nano processes the received command and activates the conveyor motor using the BTS7960 motor driver.

Metal Detection and Monitoring

Object Movement: The conveyor motor continuously moves objects through the inspection zone.Metal Detection: The LJ12A3-4-Z/BX inductive proximity sensor continuously monitors objects passing on the conveyor belt. When a metallic object enters the sensing range, the sensor generates a detection signal.Feedback and Indication: The Arduino Nano receives the sensor signal and updates the LCD display. Indicator LEDs and the buzzer provide visual and audible status feedback to the operator.

Automatic Sorting Operation

Sorting Action: After metal detection, the Arduino Nano activates the MG996R servo motor. The servo rotates to a predefined angle and diverts the metallic object into a separate collection path.Normal Object Flow: Non-metallic objects continue moving along the conveyor without interruption.Emergency Operation: If the emergency stop switch is pressed, the conveyor motor, servo motor, and all system outputs are immediately disabled to ensure safe operation.Output: The system successfully separates metallic and non-metallic objects while providing reliable wireless monitoring and control through LoRa communication.

Arduino Nano

The Arduino Nano is the main controller used in both transmitter and receiver units of the proposed system. It is based on the ATmega328P microcontroller and is responsible for processing sensor inputs, controlling wireless communication, operating the conveyor motor, and managing the sorting mechanism. Due to its compact size, low power consumption, and sufficient input/output pins, it is widely used in industrial automation and embedded applications.

Microcontroller: ATmega328P
Operating Voltage: 5V
Input Voltage: 7V–12V
Digital I/O Pins: 14
Analog Input Pins: 8
Flash Memory: 32 KB
SRAM: 2 KB
Clock Speed: 16 MHz

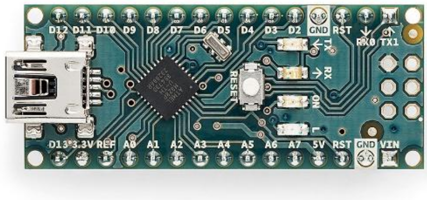

Fig. 3. Arduino Nano

E32-433T30D LoRa Module

The E32-433T30D module is used for long-range wireless communication between transmitter and receiver units. It operates at 433 MHz and provides reliable data transmission over long distances with low power consumption. The module enables remote monitoring and control of the conveyor sorting system.

Frequency: 433 MHz
Communication Range: 1–5 km (LOS)
Supply Voltage: 3.3V
Communication Interface: UART (TTL Serial)
Low Power Consumption
High Communication Reliability

Fig. 4. E32-433T30D LoRa Module

LJ12A3-4-Z/BX Inductive Proximity Sensor

The LJ12A3-4-Z/BX inductive proximity sensor is used for detecting metallic objects on the conveyor belt. The sensor operates without physical contact and generates a digital signal whenever a metal object enters its sensing range. Its reliable detection capability makes it suitable for industrial automation and sorting applications[5].

Sensor Type: Inductive Proximity Sensor
Detection Distance: 4 mm
Operating Voltage: 6V–36V DC
Output Type: Normally Open (NO)
Output Signal: Digital

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Fig. 5. LJ12A3-4-Z/BX Inductive Proximity Sensor

BTS7960 Motor Driver

The BTS7960 motor driver is used to control the conveyor motor. It supports high-current applications and provides PWM speed control, making it suitable for industrial conveyor systems. The driver offers reliable motor operation with built-in protection features [3].

Operating Voltage: 5V–27V
Current Capacity: Up to 43A
PWM Speed Control
Thermal Protection
Overcurrent Protection

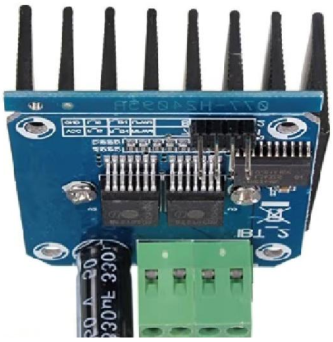

Fig. 6. BTS7960 Motor Driver

MG996R Servo Motor

The MG996R servo motor is used as the sorting mechanism in the proposed system. When a metallic object is detected by the sensor, the servo motor rotates to a predefined angle and diverts the object into a separate collection path. Its high torque and fast response ensure accurate sorting[4].

Operating Voltage: 4.8V–7.2V
Rotation Range: 180°
Stall Torque: 11 kg-cm
High Speed Response

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Fig. 7.MG996R Servo Motor

12V 300 RPM DC Geared Motor

The conveyor belt is driven using a 12V, 300 RPM DC geared motor. The motor provides sufficient torque and stable speed for smooth transportation of objects along the conveyor belt. It ensures continuous and reliable operation during sorting processes.

Rated Voltage: 12V
Speed: 300 RPM
High Torque Output
Low Noise Operation
Continuous Duty Operation

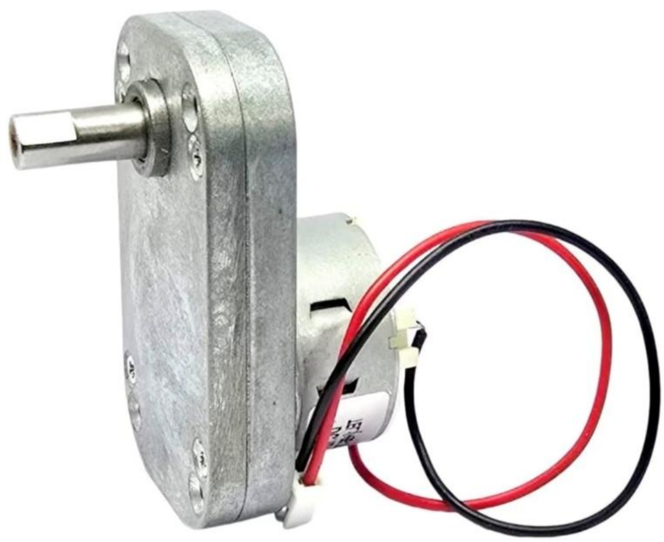

Fig. 8.12V 300 RPM DC Geared Motor

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Prototype Image:

Fig. 9. Developed Prototype of LoRa-Based Wireless Conveyor Metal Sorting System

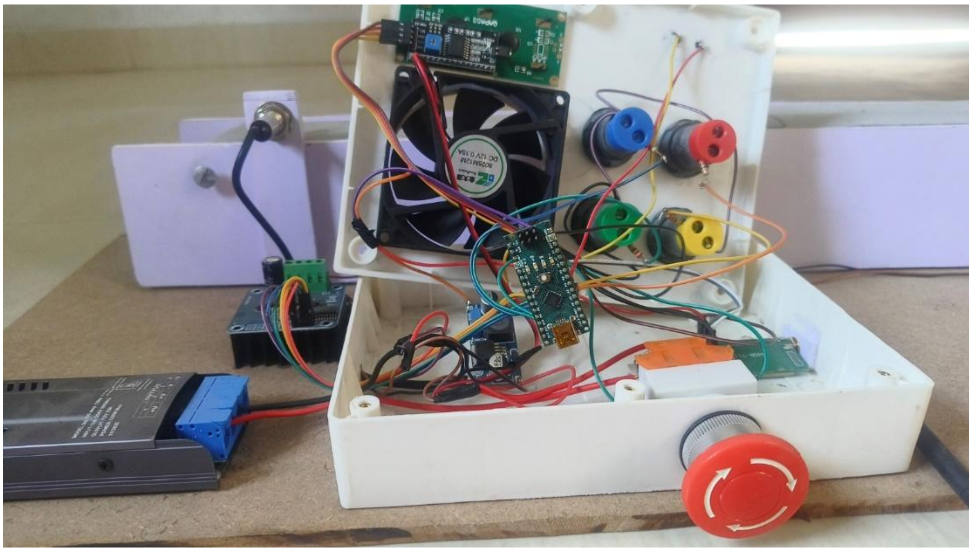

Fig. 10. Internal Hardware Arrangement of Transmitter and Receiver Unit

IV. CONCLUSION

The LoRa-Based Wireless Conveyor Metal Sorting System was successfully designed and developed for industrial automation applications. The system utilizes Arduino Nano controllers, E32-433T30D LoRa modules, an inductive proximity sensor, a BTS7960 motor driver, and an MG996R servo motor to automate metal detection and sorting operations. Experimental results demonstrated reliable wireless communication, accurate metal detection, and efficient sorting performance. The proposed system reduces manual effort, improves productivity, and provides a cost-effective solution for modern material handling industries.

V. FUTURE SCOPE

The future scope of the LoRa-Based Wireless Conveyor Metal Sorting System lies in enhancing automation, monitoring capabilities, and industrial integration. The following improvements can be implemented in future versions:

1. IoT and Cloud Monitoring

The system can be integrated with IoT platforms to enable real-time monitoring and remote control through cloud-based dashboards and mobile applications.

2. AI-Based Object Classification

Future systems can utilize computer vision and machine learning algorithms to identify and classify different types of materials instead of only detecting metallic objects.

3. SCADA System Integration

The conveyor sorting system can be connected to SCADA platforms for centralized monitoring, data logging, alarm management, and industrial process control.

4. Predictive Maintenance

Additional sensors can be incorporated to monitor motor health, vibration, and operating conditions, enabling predictive maintenance and reducing unexpected downtime.

5. Industry 4.0 Implementation

The proposed system can be integrated with smart factory technologies to support automated production lines, real-time analytics, and intelligent decision-making processes.

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